FIRE MANAGEMENT

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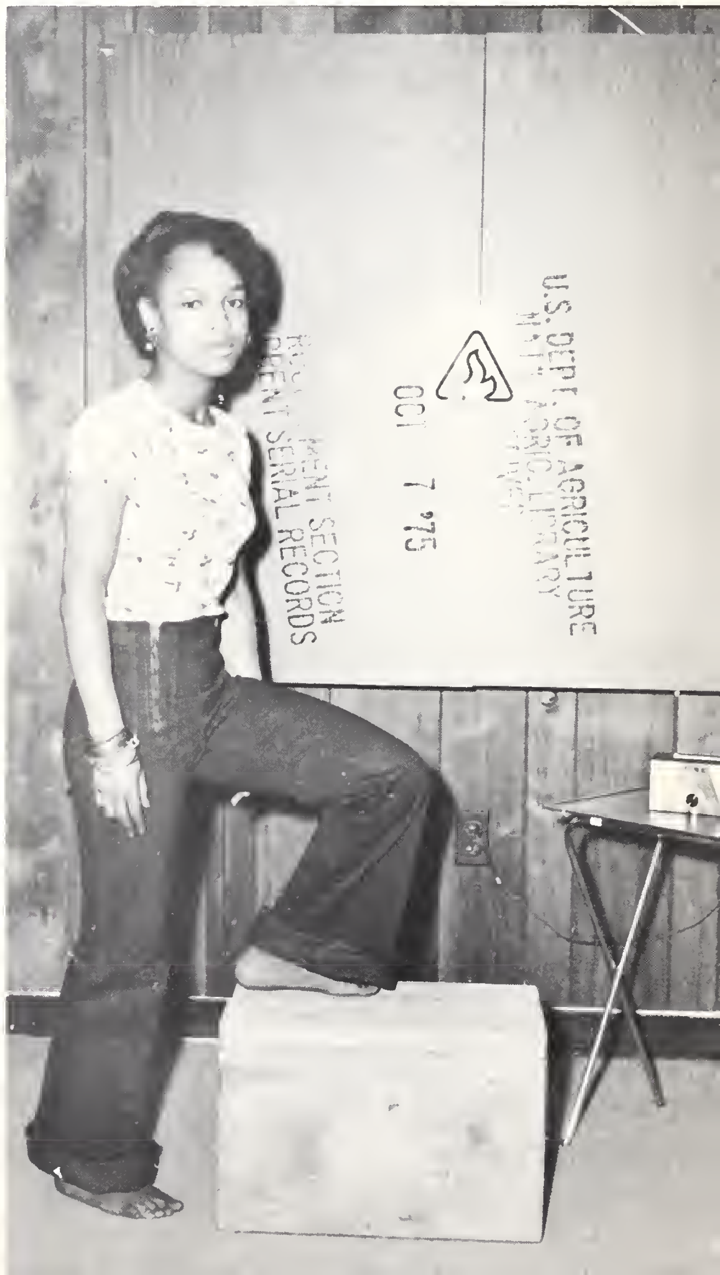
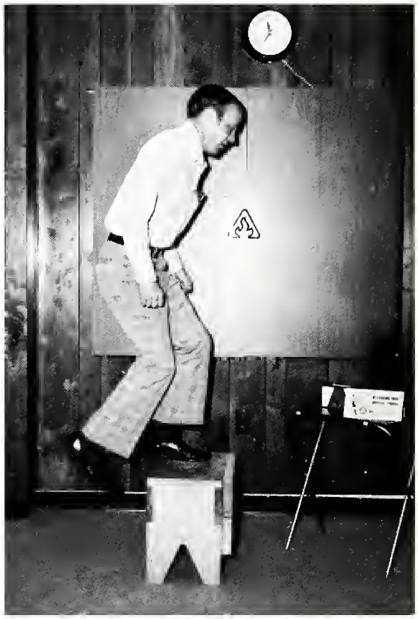


FIRE MANAGEMENT

An international quarterly periodical devoted to forest fire management



A firefighter must have stamina, endurance, and a high level of physical fitness if he is to successfully perform sustained hard work.

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Physical Fitness For Firefighters Can You Measure Up?

Jim Abbott

Fighting wildland fires is one of man's most strenuous jobs. Working on steep terrain and in a hot, smokey environment demands maximum energy output. Firefighting working conditions exceed most jobs in sheer energy expenditure. Couple these conditions with a contemporary American lifestyle, which is long on labor-saving devices and short on physical demand, and you can easily recognize the need to measure physical fitness. (See table 1.)[1]

FITNESS COMPARISON*

SUBJECTS	COUNTRY	MEN	WOMEN
Untrained Young (age 20-30)	U.S.A.	43	30
Untrained Young (age 20-30)	Canada	49	36
Untrained Young (age 20-30)	Scandinavia	59	43
Active Young (age 20-30)	U.S.A.	52	39
Active Young (age 20-30)	Canada	55	—
Active Young (age 20-30)	Scandinavia	59	—
Champion Distance Athletes	U.S.A.	82	68
Champion Distance Athletes	Scandinavia	82	68
Untrained (40-50 yrs.)	U.S.A.	36	—
Untrained (40-50 yrs.)	Canada	39	30
Untrained (40-50 yrs.)	Scandinavia	45	34
Trained (40-50 yrs.)	U.S.A.	58	—

*ml. of oxygen consumed per kg of body weight per min.

What has been done about this? The Forest Service, U. S. Department of Agriculture, now requires minimum physical fitness standards for firefighters. Standards have been in effect in some areas of the Forest Service for 2 years, however, in 1975 the requirement became mandatory nationally. Department of Interior agencies have cooperated in this effort and are in the process of establishing identical physical fitness standards.

Figure 2. Equipment needed to carry out step test.

Test is Fair

It is important to measure fitness fairly and without discrimination. Specific physical requirements of various jobs must also be recognized. Chin-ups for example, would not be an appropriate measurement of a physical requirement if the muscles used to do chin-ups are unrelated to a specific job task. The duration of a particular task must also be determined. For these reasons, simple calisthenic exercises, while healthful, are not necessarily a measure of fitness. The testing procedure was designed to be safe and easy to administer, fairly and consistently. The 5-minute step test is within the capability of the average person to accomplish and does not require unusual agility or skill.

The most obvious physical requirement for wildland firefighters is endurance. Firefighting duties generally do not require great strength but do require physical stamina. The ability to continue work after long hours is critical. How is endurance measured?

There is a direct correlation between the ability to continue to work and the amount of oxygen utilized by the

Please turn to page 4

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body. The combination of food and oxygen to produce energy is accomplished by aerobic or oxygen-using enzymes, tiny sub-cellular particles within the muscle fiber.[2] The ability to take in, transport, and utilize oxygen is basic to physical working. This aerobic capacity is well explained in Dr. Brian Sharkey's book, *Physiological Fitness and Weight Control,* as well as Cooper's book, *New Aerobics.* This article is not a discussion of exercise physiology. Interested readers should study these books to gain a basic understanding before undertaking a program to measure physical fitness.

Scientists have long been able to accurately measure man's oxygen consumption in laboratory tests. The development of a simple test which can be conducted in normal surroundings was essential to the success of this program. The Forest Service Equipment Development Center at Missoula, Mont., and the Human Performance Laboratory of the University of Montana developed a submaximal step test based on concepts developed by Swedish physiologists and later checked in laboratories throughout the world.[3]

The Test

The test consists of stepping up on a 15¾-inch (13-inch for women) bench for 5 minutes at a pace of 90 beats per minute. (See directions, figure 1, and equipment needed, figure 2.) The post-exercise pulse rate is taken, and through a calculation which adjusts age, weight, and sex factors, the aerobic capacity is determined. The final readout is a mililiter of oxygen consumed per kilogram of body weight per minute (ml/kg/min). Follow the step test calculation through figures 3 and 4 on page 5.

Since the test measures an individual's capability to take in, transport, and utilize oxygen, it is nondiscriminatory. The endurance requirement for arduous duty is the same whether young or old, male or female. While the physiologies of men and women differ, the aerobic capability of each must be sufficient to meet the physical demands of the specific job.

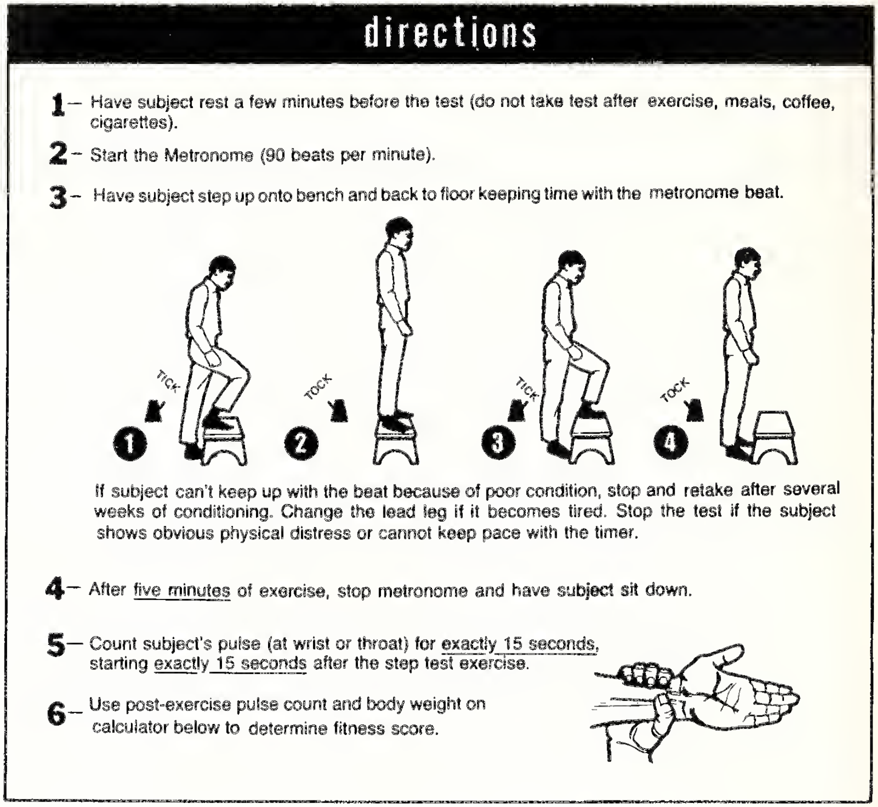


Figure 1. Directions for carrying out the Step Test.

Men and Women Must Meet Same Level

The fact that different stool heights are used for men and women often raises questions, usually from men who feel they are taking a harder test. The reason for the difference in stool heights goes back to the origin of the test and the data upon which the test was developed. People should also note that different scales are used to calculate the aerobic capacity, too, and that women must meet the same levels as men for the same jobs. This means a woman's aerobic capacity must be 45 ml/kg/min to qualify for a line job just as a man's capacity must be 45. The difference is in the means of calculation.

The step test is a simple, submaximal test, hence safe and easy to administer. If someone has trouble with the test for psychological or coordination reasons, however, an "aerobic" run of 1½ miles can be substituted. Comparable levels are:

1½ mile 12 minutes or less = 45
1½ mile 12.01 to 14.00 min. = 40
1½ mile 14.01 to 16.45 min. = 35
1½ mile more than 16.45 = Below 35

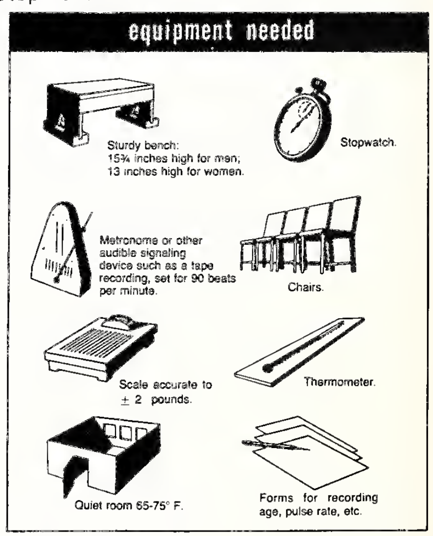


Figure 2. Equipment needed to carry out step test.

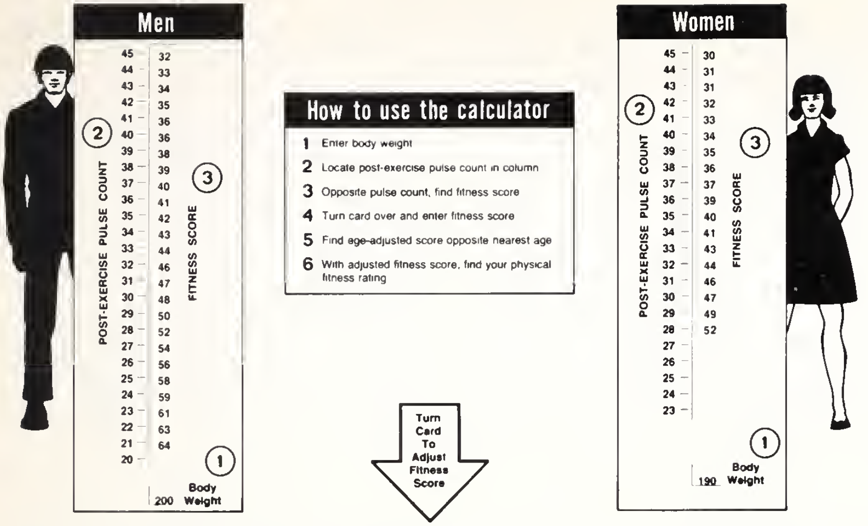


Figure 3. Example of how to use calculator. Note slide chart is set for men having a body weight of 200 pounds.

The run is a maximal exercise and hence requires caution before undertaking. A physical examination and good health may be sufficient precautions for those under 35 years old. Those over 35 are required by the Forest Service to have a stress EKG within 3 months as well as a physical examination before undertaking such a run. The Forest Service prefers the step test but will accept the run as an alternative.

The requirements for wildland firefighters are set at 35, 40, and 45 (ml/kg/min), depending on the nature of the job. Generally, the arduous front line positions require 45 while support and administration jobs require lower levels.

Exercise Program is Necessary

A basis for judging how appropriate any program might be is to compare the requirements with the population as a whole. Levels of 35-45 are not unreasonable, but will not be automatically met by the average American without an exercise program.

The next phase of the physical fitness program for wildland firefighters is to determine specific strength and agility requirements and the feasibility of tests to measure them. While endurance is the most important, there probably are some minimum muscular strength demands which a person should have to work safely and efficiently. These areas will be the subject of research this summer. The work done by many urban fire departments should be of value in this effort.

Good Health — A Benefit

The greatest benefit of the physical fitness requirement has been the encouragement for people to begin exercise programs. Forest Service, USDA personnel, from novice firemen on part-time crews to Regional and Washington Office Fire Management leaders, can be found running or otherwise exercising on a regularly planned basis. Careful aerobic exercise periods at training heart rates for 15 minutes or more a day are common. One measure of *training heart rate* is 80% of maximal heart rate. Exercise need not be maximal to elicit an aerobic training effect. *Training heart rate* indicates a safe but effective intensity of exercise. The other benefits, weight control and general good health resulting from an exercise program, accrue naturally.

The Payoff

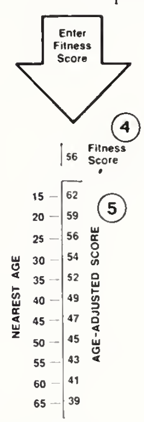
The big payoff for the job is in the health and safety of the individual. We anticipate less accidents of all types due to fatigue. The ability to control a pulaski swing, handle a chain saw safely, or simply walk in rough terrain should improve. Besides safety, an appreciable effect on production and morale is expected. The crew that is totally spent physically should be uncommon, and the ability to work hard for a full day should improve.

Endurance Important

Veteran firefighters have long been aware of great differences in the work capability of crews. The specially

(Use Age-Adjusted Score) 6

NEAREST AGE	Physical Fitness Rating – Men						
15	57+	56-52	51-47	46-42	41-37	36-32	31-
20	56+	55-51	50-46	45-41	40-36	35-31	30-
25	55+	54-50	49-45	44-40	39-35	34-30	29-
30	54+	53-49	48-44	43-39	38-34	33-29	28-
35	53+	52-48	47-43	42-38	37-33	32-28	27-
40	52+	51-47	46-42	41-37	36-32	31-27	26-
45	51+	50-46	45-41	40-36	35-31	30-26	25-
50	50+	49-45	44-40	39-35	34-30	29-25	24-
55	49+	48-44	43-39	38-34	33-29	28-24	23-
60	48+	47-43	42-38	37-33	32-26	27-23	22-
65	47+	46-42	41-37	36-32	31-27	26-22	21-
	Superior	Excellent	Very Good	Good	Fair	Poor	Very Poor



(Use-Age Adjusted Score) 6

NEAREST AGE	Physical Fitness Rating – Women						
15	54+	53-49	48-44	43-39	38-34	33-29	28-
20	53+	52-46	47-43	42-36	37-33	32-28	23-
25	52+	51-47	46-42	41-37	36-32	31-27	26-
30	51+	50-46	45-41	40-36	35-31	30-26	25-
35	50+	49-45	44-40	39-35	34-30	29-25	24-
40	49+	48-44	43-39	38-34	33-29	28-24	23-
45	48+	47-43	42-36	37-33	32-26	27-23	22-
50	47+	46-42	41-37	36-32	31-27	26-22	21-
55	46+	45-41	40-36	35-31	30-26	25-21	20-
60	45+	44-40	39-35	34-30	29-25	24-20	19-
65	44+	43-39	38-34	33-29	28-24	23-20	19-
	Superior	Excellent	Very Good	Good	Fair	Poor	Very Poor

Level I	Level II	Level III	Level IV	Level V
55+	54–50	49–45	44–40	39–35

AGE ADJUSTED SCORE OF 45 OR ABOVE RECOMMENDED FOR SUSTAINED ARDUOUS WORK

FITNESS CATEGORIES FOR SUSTAINED HARD WORK

Figure 4. Note slide chart is set for a fitness score of 56 and an age adjustment is made to determine physical fitness.

Please turn to page 20

Building Fireline With *Explosives*

C. L. (Bud) Clarke

At 1200 on September 16, 1974, I parachuted to the Outlaw Fire in the Idaho Panhandle National Forest to head a fireline blasting team with other smokejumpers already on the fire. Our mission was to use a new linear fireline explosive to help contain the fire.

Explosive Cord Airlifted

Two bundles of the explosive cord were dropped from our Twin Beech aircraft over the Round Top helispot shortly after we had made our jump. The parachute on the second bundle failed to open, and the 200 feet of cord it contained hit the ground at an estimated 120 MPH. Only a plastie screw connector on one length of cord was slightly damaged, but the cord remained usable.

Explosive Cord Composition

The linear explosive we were using consisted of four strands of 500 grains-per-foot detonating eord, each about ½ inch diameter, with 1,500 grains-per-foot diammonium phosphate (DAP) eontained in a latex-coated overbraid. Each strand has a mixture of 70 percent PETN explosive and 30 percent cooling salt (to prevent fire starts). The latex coating also was impregnated with cooling salt.

Development

Developmeni of this linear explosive system began about 5 years ago when the Missoula Equipment Development Center was asked to determine if explosives could be used safely to clear fireline without starting secondary fires. The broader overall objective was to develop a system that would enable small, highly mobile crews to construct fireline rapidly.

Carrying straps are an integral part of fire-line cord container. It can be picked up, and fire-line cord deploys out of container as man walks away.

Before fireline blast in logs, slash, and brush.

After fireline blast in logs, slash, and brush. Note cleared out area down to mineral soil.

Fireline Building

We arrived at the fire about 1800 and, with the help of three other smokejumpers, strung 200 feet of the cord. It was packed in boxes designed for backpack carry. A knockout plug in the back of the box allowed access to the end of the cord, which fed out for instant deployment. This 200 foot length was detonated at 1810.

Screw connectors were attached to the ends of each 100-foot length allowing any number of lengths to be coupled together and detonated with a single ignitor. On one occasion the cord did not propagate between the connectors, so I laid another 100 feet and connected it parallel to the unexploded section with about 6-8 inches overlap and taped the two together. I detonated it at 1840. This method worked well. The crew then strung 300 feet to complete that portion of fireline. It was exploded at 1915.

The 500-foot line constructed by the explosive was nearly 100 percent complete. The only task remaining was to saw out a few logs that the blast had not removed. The explosive's blasting action packed the area on both sides of the line with dirt further retarding the spread of the fire. That completed the first day's work.

C. L. (Bud) Clarke is Smokejumper Supervisor at Missoula Smokejumper Base, Forest Service, USDA.

On September 17 we arrived at the line at 0630, ahead of the day crews. While three men unpacked the gear, the proposed line was scouted. Five of us laid out 400 feet of cord for 300 feet of line to be built. The extra 100 feet was cut up to go around and through downfall and slash. The cord was detonated at 0815. At 0840 we hooked up the last 100 feet of fireline explosive and detonated it.

Results

The operation was very successful. Our blasting did not hinder the fire team's operation or the men working on the line, but instead, fit smoothly into the overall firefighting effort. Once the explosive had done its work, a crew would move right in on the blasted line. We worked under the direction of the line boss, who told us which areas to work in and who to contact in those areas.

The primary advantage of the explosive is the increased rate of line construction per man hour. Our five man blasting crew built 1,000 feet of line in two hours in fuels of medium to high resistance to control. The fireline explosives constructed 15 chains of line 50 percent faster than a high-proficiency crew in a period of two hours with a substantially lower fatigue factor after two hours.

The amount of cleanup varied, depending on fuel types, but the major task was sawing out material more than 6 inches in diameter. Mopup was also reduced since residue was shredded and dispersed, and environmental impact was minimal due to the feathering action of the line.

Safety

The explosives system is safe. It has successfully undergone safety tests at the Naval Weapons Center. Also, an explosives detonator — the Exploding Bridgewire (EBW) — was recently approved for Forest Service use. The EBW detonator's principal advantage is its increased safety for blasting

Before fireline blast in light brush cover.

After fireline blast in light brush cover.

Please turn to page 13

Explosives Build Fireline in Canada

D. W. Langridge

The British Columbia Forest Service has tested and found 840 grain-per-foot detonating cord useful as a fireline building tool. Detonating cord can be an aid to or an alternate method of building firelines. The prototype cord selected by the British Columbia Forest Service meets their requirements of power-to-weight ratio, flexibility, and color and does not ignite ground fuels.

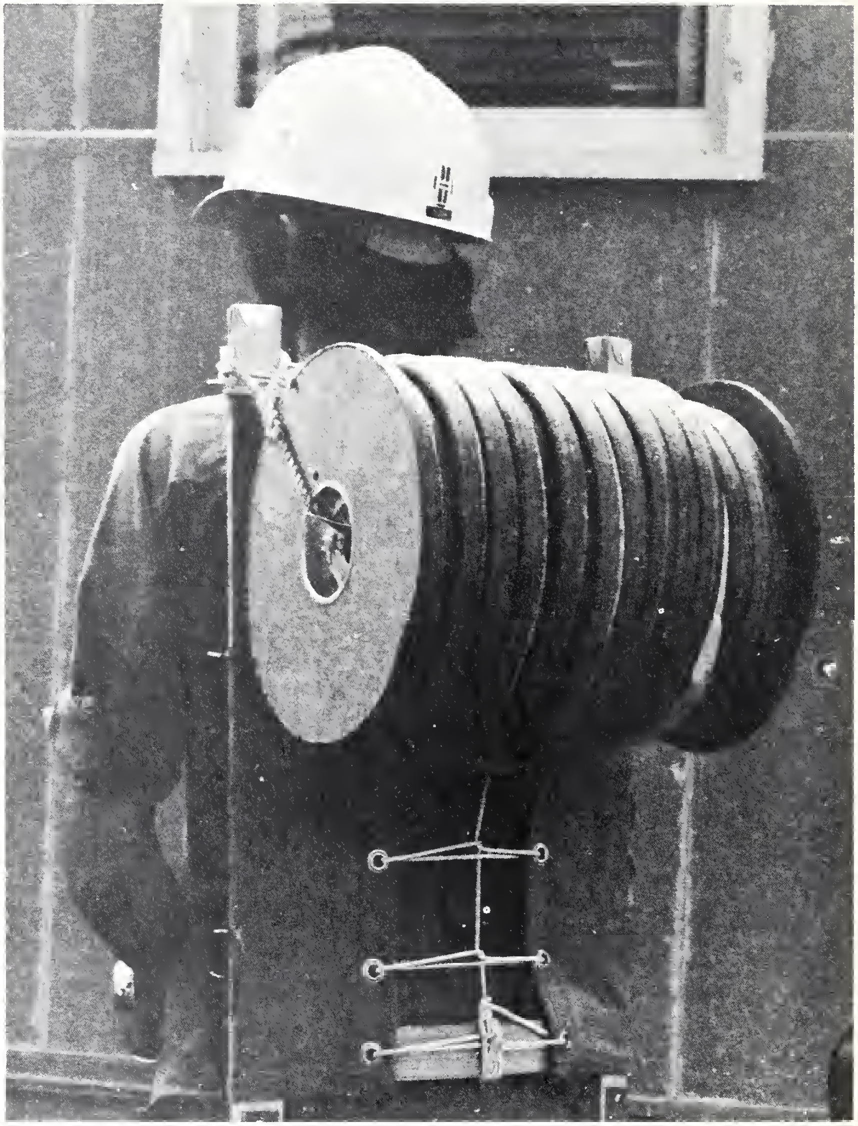
Advantages of Detonating Cord

A single lay of cord will do an adequate job in most interior dry belt forest types. Two cords laid side by side and detonated simultaneously will accomplish 70 percent of the task of line construction in the more difficult forest types.

The advantage of speed of fireline construction using detonating cord outweighs its higher cost compared with conventionally built hand lines. The dollar savings resulting from reduction of final fire size and damage values offsets the increase of construction costs.

Because detonating cord is an explosive, the crews using it must be skilled in the proper methods of transporting, storing, and handling the cord. They must have a foolproof safe procedure for constructing firelines.

Even though there are storage and transportation problems, detonating cord is a beneficial tool for initial attack crews, especially in remote areas where there is a lack of manpower.



A spool of 200 feet of 840 grain per foot detonating cord attached to a pack-board ready for transport to a fire.

Detonating Cord Ineffective in Logging Slash

Detonating cord is ineffective in logging slash. The time-consuming and difficult task of laying out the cord discourages its use in logging slash.

In other fuel types, the cord can make an adequate line. If more power is needed, it can be obtained by detonating two or more strands simultaneously.

Data collected to date indicate a single strand of 840 grain-per-foot cord will construct an adequate line in sagebrush, open yellow pine Douglas-fir sites and most immature Douglas-fir-larch sites. A single strand of cord will do 60-100 percent of the total job of line construction in all types where total duff and humus layer is less than 1½ inches in depth and the root mat is light.

Where deeper duff and humus

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layers are encountered or when the root mat is considered medium to thick, two strands of cord can be employed. The data recorded indicated that in most types two strands (2 x 840, yielding 1680 grains/ft.) will do an adequate job. The work completed by the cord exceeded 70 percent of the total task of hand line construction.

Detonating Cord Builds Line Faster — Reduces Total Costs

The 1973 field trials showed use of detonating cord for fireline construction to be feasible, and because the speed of construction results in reduction in fire size, there is a savings in cost plus damage. When detonating cord is used on fires of 1 to 5 acres initial attack size, with moderate rates of spread, a final fire size can be expected to be 78 percent of the area of a fire controlled with hand tools.

Use of detonating cord can be justified when its use eliminates the necessity of extra flights for secondary or support crews into fires in remote

Safety

It is erroneous to flatly state there is no danger when using high-powered detonating cord for fire control. It is essential that a foolproof procedure be strictly followed and that the entire crew become experts in storage, transportation, handling, and fireline use of the cord. All personnel using the cord must employ safe working practices.

Although detonating cord is an explosive and must be treated as such, it is an explosive in the safest form. The Missoula Equipment Development Center of the USDA Forest Service conducted safety and durability tests on a product similar to the 840 grain-per-foot cord. ("Safety and Durability of the Fireline Explosive Cord—Austin 1973"). These tests included bullet impact, burning, crushing, chopping, dragging, bending, and air dropping. In all cases, the cord failed to detonate as a result of damage or mishandling. All indications are that the 840 grain-per-foot cord has similar characteristics.

The method of initiation using fuse assemblies is simple and safe but it still presents a major concern. The minimum 3-foot fuse creates a 2-minute time period which allows crew members to easily disperse to prearranged safe watch guard locations. At the same time, this period can be one of danger to unsuspecting firefighters, the general public, or low-flying aircraft approaching the fire area. Until other methods of initiation are employed, it is essential that the entire crew be on constant watch for unsuspecting intrusion. This includes radio monitoring birddog aircraft.

Cross section design of 840 grain per foot detonating cord—comprised of 2-420 grain per foot cord and 1 ounce/foot of fire retardant.

Future Needs

Sufficient 840 grains-per-foot detonating cord will be made available to continue operational testing of the cord on actual fires in the 1975 fire season, after which the program will be re-evaluated. This will be done by pre-trained ranger station crews from their actual experience on fires.

Please turn to page 20

Wilderness Fire Management

Leonard F. Krout

Modern wilderness area management concepts are forcing a change in fire suppression tactics and strategy on wilderness area fires. Special interest groups and concerned individuals are ever watchful and increasingly vocal in their input regarding management procedures. New concepts encompass the general theory of "laying as light on the land" as we possibly can in all our uses of wilderness lands and in our management efforts on these lands. They include the pack-in pack-out policy, restrictions of numbers of pack and saddle stock on main trails, relocation of over-used camp sites, no new construction of helispots, deletion or reduction of signing, and many, many more policies, all designed to use but not scar our wilderness lands and to maintain them in their true wilderness state.

A Change in Tactics

Northern Region smokejumpers have accepted the challenge to fight wilderness fires in a manner consistent with this philosophy. They have adapted and are committed to new fire suppression standards. New tactics and strategy include: total fire camp and fire area trash cleanup (all nonburnable material is to be packed out, nothing is to be buried), constructing only the minimum size fireline necessary to affect control of the fire (scar the ground only to the extent necessary

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Please turn to page 10

Wilderness Fire Management

from page 9

"Tango Cabin" Fire. Bob Marshall Wilderness Area, Flathead National Forest, Montana

to stop the fire spread), taking advantage of any cold line (hand feel for heat and if none, dig no line), falling only what green timber must be felled to stop the fire spread (do a lot more limbing up and a lot less falling of green timber), and locating firelines to take advantage of natural firebreaks whenever possible.

New Strategy

The use of motorized equipment in the wilderness area is consistent with the direction given by the local Forest Supervisor. This direction in the Northern Region generally restricts the use of motorized equipment (power saws, power pumps, and helicopters) in normal fire situations, but may allow this use at times to prevent undesirable fire damage or when it is necessary to expedite the return of smokejumpers, firefighters, and fire equipment for use on other fire assignments in the Region. Where use of pack stock to retrieve fire equipment may unduly scar the landscape, helicopters may be used. If helispots must be built, the edges are "feathered" into surrounding vegetation to simulate natural openings.

Dozer fireline construction in heavy lodgepole pine.

In complying with new wilderness fire strategy, a smokejumper is occasionally exposed to parachute and tool packouts of up to 6 miles cross country to a main trail with a 90 to 125 pound pack per man, then trail walkouts of from 25 to 45 miles to the end of the road or to a remote airstrip outside the wilderness. Good physical conditioning is absolutely essential. Smokejumping continues to be an ideal method of manning wilderness area fires. These well-trained and experienced firefighters readily apply the new concepts of wilderness fire management and comply with the established policies that we ask of all wilderness users.

A Challenge

New fire suppression standards for wilderness area fires give the fireman a real challenge. He must realize that he is still totally responsible for stopping the spread of the fire and for investigating cause, mopping up, and declaring it out as he was before, but must now accomplish the same goal with the least possible disturbance to the land. It requires the same aggressive initial attack action coupled with a sensitivity for the land and "Mother Nature." A thorough knowledge of fire behavior, an ability to predict probabilities and to interpret and predict fire weather, an esthetic sensitivity, and the judgment to put it all together are all vital to his success. He's still totally responsible for all fire action. He must determine where and to what extent he can minimize line construction and still stop the fire spread. What green timber must be felled and bucked and what can be limbed up and saved? Greater care of line location and construction is vital. All in all, he must think and put his ability and reputation on the line. It is a real challenge.

FIRE MANAGEMENT

A Change in Philosophy

Necessary to the success of the new program is an understanding and a change in philosophy of our district and forest land managers. Historically, fire crews have been judged on the condition of the fire area when the crews left. Did they leave a well-trenched fire? Did they remove *all* fuels within the fireline? Did they cup-trench below steep areas? Did they establish a "bone-yard" outside the fire perimeter for partially burned fuel that was declared out? Did they trench the "bone-yard?" Such criteria have historically been used to judge the performance and proficiency of fire crews. "Potato-patching mopup" or completely digging up and turning over the soil in the whole area, may be entirely necessary to assure oneself that a portion of a fire is really out, but it is not realistic to require the entire burned area to be "potato-patched." Let's disturb only what needs to be disturbed. Unless otherwise directed, Northern Region smokejumpers will "potato-patch" only those areas requiring that kind of treatment to ensure complete and timely mopup.

Even more professionally demanding, and further complicating the fire suppression picture, are the new concepts of allowing fires to burn with little or no suppression to a predetermined prescription. Although these concepts may be considered by some as "way-out" and radical, they are in tune with the belief that fire is a natural force in wilderness and is vital in maintaining these lands for the purpose for which they are dedicated, in this case, true wilderness. Here our management objectives are clear.

Fireline constructed with handtools.

Natural Prescribed Burning

One job we must do, if we are to achieve public understanding and support of these new concepts is to eliminate the term "let burn" in reference to our program of allowing some fires to burn naturally to a predetermined prescription. The term causes misunderstanding. Instead of calling them let-burn areas, we call then *Natural Prescribed Burn Areas.*

These new fire suppression standards can be applied to large project fires in the wilderness area with the same degree of success expected as with the small fires. Proper line location becomes much more important on the large fires. As much as we all like to use direct attack to minimize the burn area and because of the inherent safety to crews it provides, the use of the new concepts might well dictate that we sacrifice a certain area containing a heavy jackpot of fuel and locate our fireline in a site where a smaller handline can be more effective in stopping the spread of the fire, such as on a spur ridge, etc. Then the jackpot can later be burned out after proper preparation and with proper firing techniques. The total fire effort might well be no greater than if we followed the concept of minimizing burned acreage.

New Developments Will Help

In future years as our suppression efforts become more sophisticated, we may evolve still more specialized wilderness techniques, such as: colorless fire retardants or short-term coloration for fire retardants; precision-built explosive constructed fireline perhaps applied by helicopter; disposable, bio-degradable packaging; and vastly expanded night capability. The latter holds much promise indeed. If we are able to take the darkness away, we rid our-

Illustration of excessive cutting of a handline.

selves of virtually all of the trauma connected with night firefighting operations. We then can take advantage of all of the normally ideal nighttime conditions such as cool temperatures, higher humidities, little or no wind, etc. Not only are these conditions ideal for firefighting, they are also ideal for air operations. Recently tested night vision goggles are now a reality and open up an

Illustration of less falling and more limbing up of a handline.

Please turn to page 19

Developing Performance Guides For Specific Air Tankers

Charles W. George

Resource management agencies can now develop performance and mission-planning guides that will allow more flexible and efficient use of air tankers. A method for determining tanker performance through static testing and a basic format for user guides has been developed by the Northern Forest Fire Laboratory and Honeywell. The guides present data on specific aircraft in graphs and tables that will help the tanker pilot, air attack specialist, and man on the fireline obtain optimum retardant coverage under various operational conditions. Each guide contains the following information:

Coverage Level	Recommended For: Fuel Model	Description
1	A	Grasses; tundra, and open desert shrub lands
2	C	Conifer timber with grass understory
	F	Brushfields with much green material
3	D	Shrublands under 6 feet in height (such as sagebrush)
	E	Hardwood litter after leaf drop
	H	Closed conifer timber with litter only
4 or more	B	Hard chaparral and other high (6-foot) flammable shrubs
	G	Closed, old conifer timber with litter and dead, down limb wood.
	I	Conifer slash

For creeping or smouldering fires reduction of one coverage level may be considered.

Figure 1. Recommended retardant coverage levels (expressed in gallons/100 ft²⁄₃) for fuel models identified in the National Fire Danger Rating System.

Charles W. George is Research Forester, USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah 84401, stationed in Missoula, Montana, at the Northern Forest Fire Laboratory.

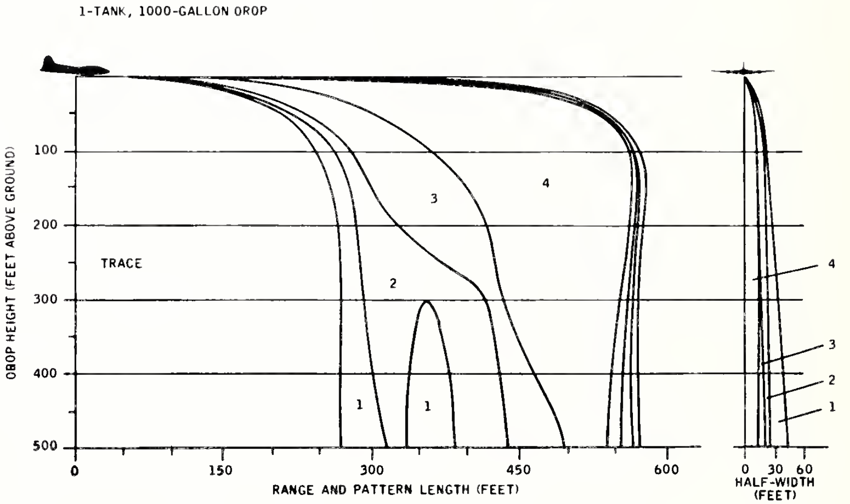


Figure 2. Pattern footprint (coverage characteristics) for a single-tank drop (1,000 gal) of gum-thickened retardant [Phos-Chek XA, Gelgord and Gum Thickened Fire Trol 931 (LC).]

- *General Information.*—A brief description of the aircraft and its tank and gating system.
- *Retardant Coverage Requirements.*—The recommended coverage level for each of the National Fire Danger Rating System fuel models (figure 1).

- *Pattern Footprints*—Plot of retardant pattern coverage levels for various types of drops and retardants, and instructions for interpretation. (An example of a pattern footprint for a single-tank drop of gum-thickened retardant from an Aero Union B-17 is shown in figure 2.)
- *Best Strategy*—Enables quick selection of the best number and sequence of tanks to be employed for specific coverage requirements and line length. General capability and safety limits are also shown. (Figure 3 charts best release strategy for a single-tank trail drop of waterlike retardant from the Aero Union B-17.)
- *Detailed Tables.*—Provide the basis for developing the best strategy charts and show the expected lengths of retardant line and specific intervals for successive tank releases to achieve maximum coverage at a large number of coverage levels and altitudes.

Development of air tanker guides begins with the collection of flow rate data on the tanking system by means of a float gage that records the level of the upper retardant surface in a single tank as a function of time.

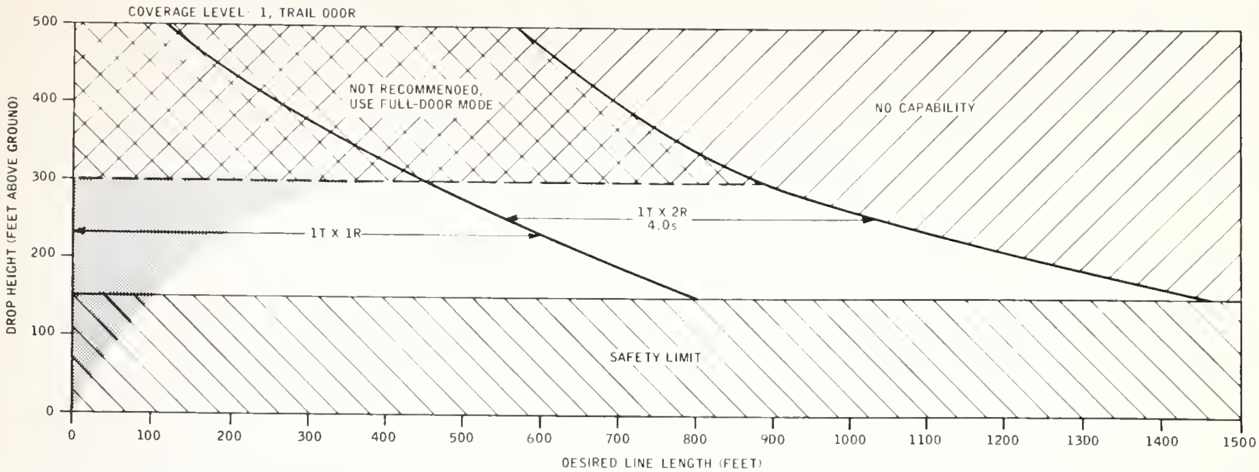


Figure 3. Best release strategy chart for a single-tank trail drop of a waterlike retardant [Fire-Trol 100, Fire-Trol 931 (LC) and Water] from Aero Union B-17
T = Tank(s) released at one time. R = Successive releases s = seconds between successive releases.
Shaded Area = Region of limited accuracy in direct attack.

These data are converted to gallons released as a function of time, from an analysis of tank geometry.

Flow rate data are entered into a Honeywell-developed computer simulation capable of predicting retardant ground patterns. Because a simulated flight test takes less than 1 second of computer time, a thorough computer-generated test series examining a wide range of aircraft velocities, drop heights, and retardant types can be conducted in a few days. The output data from a series of simulated test flights are then digested, summarized, transformed into useful terms, and incorporated in guidelines for field personnel.

User guides for several air tankers have been developed and verified using static test flow rate data and actual drop test data. Thus, using these procedures, guides for any type of aircraft tank and gating system can now be developed following (1) static testing to determine the flow rate for all drop configurations, and (2) prediction of ground patterns by computer simulation.

A sample copy of the User Guides and an Instruction Manual for their use are available from: Northern Forest Fire Laboratory, Drawer G, Missoula, Mont. 59801. A 122 page report that describes technical aspects of the simulation program and development of the User Guides is available on request.

Research Publications

Following is a list of fire publications that were published during the period July 1 to December 31, 1974 and are available from:
North Central Forest Experiment Station, USDA Forest Service, Folwell Avenue, St. Paul, Minn. 55101.

Donoghue, Linda R.
1974. Prescribed burning in the central Lake States—1972.
USDA For. Serv. Res. Note NC-170, 2 p. North Cent. For. Exp. Stn., St. Paul, Minn.

Perala, Donald A.
1974. Repeated prescribed burning in aspen. USDA For. Serv. Res. Note NC-171, 4 p., illus., North Cent. For. Exp. Stn., St. Paul, Minn.

Perala, Donald A.
1974. Growth and survival of northern hardwood sprouts after burning. USDA For. Serv. Res. Note NC-176, 4 p., illus. North Cent. For. Exp. Stn., St. Paul, Minn.

Johnson, Paul S.
1974. Survival and growth of northern red oak seedlings following a prescribed burn. USDA For. Serv. Res. Note NC-177, 3 p. North Cent. For. Exp. Stn., St. Paul, Minn.

Loomis, Robert M.
1974. Predicting the losses in sawtimber volume and quality from fires in oak-hickory forests. USDA For. Serv. Res. Pap. NC-104, 6 p., illus., North Cent. For. Exp. Stn., St. Paul, Minn.

Building Fireline With Explosive
from page 7

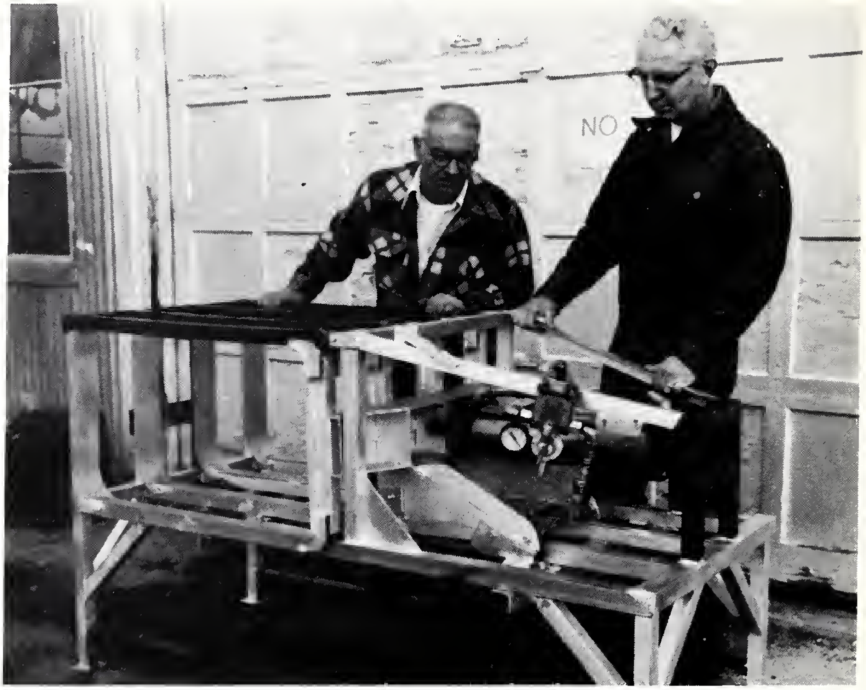
operations. Unlike the standard electrical cap, which can be set off by stray electrical currents, static electricity, and radio transmissions, EBW detonators require a precisely timed electrical charge from a special firing set. This makes them immune to accidental detonation.

Cost comparisons between fireline built with linear explosives and hand-built line have not been made yet, because the explosives are still in the early stages of field use.

During the 1975 fire season, we, along with specially trained crews in California and the Pacific Northwest will continue testing the fireline blasting system.

Improved Sleeping Bag Roller

H. Michael Jinotti



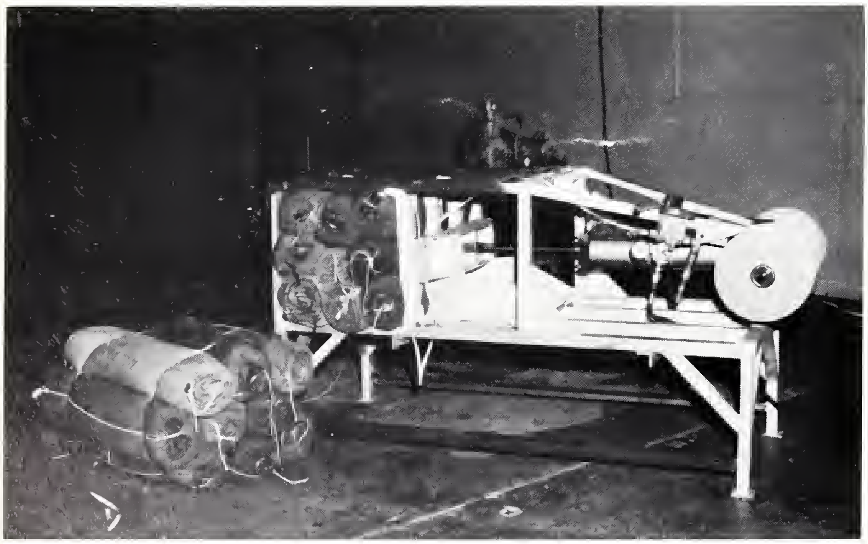
H. Michael (Tony) Jinotti, Equipment Specialist, and Edmund J. Godbout, Mechanical Engineering Technician, Missoula Equipment Development Center check out their new model sleeping roller.

Like the legendary Phoenix, the Northern Region's new sleeping bag roller arose from the ashes of the disastrous September 1974 Missoula Warehouse fire. The original model, built by the Northern Region of the Forest Service in the 1940's was destroyed in this fire, as were a number of sleeping bags and various other firefighting supplies and equipment.

Sleeping Bag Roller

Fire Management and Missoula Equipment Development personnel redesigned and built a much improved model of the older roller. Several thousand sleeping bags have been run through the new machine, at an average time of less than 1 minute per bag. Both Kapok and Dacron bags can be rolled into a compact roll in less time than was possible with the older roller. The time savings feature is significant when considering that 5,000 to 10,000 bags are rolled during an average fire season, and up to 20,000 during a severe season.

The new roller possesses a chrome-plated winding shaft that is easily withdrawn from the center of a rolled bag. Two turnbuckles provide a feature that facilitates tension mount adjustments. A safety clutch pedal engages and disengages the ½-hp electric motor drive. The roller was built in 1 week's time at an approximate cost of $850, including labor.



A new improved sleeping bag bailer showing compressed bail of nine sleeping bags.

Sleeping Bag Bailer

Another piece of equipment complementing the roller is a sleeping bag bailer. The bailer compresses and bails nine bed rolls into a compact bundle, securing them with ½-inch nylon tape. Recent modifications include the addition of a hand-operated air valve which controls the master cylinder allowing it to be operated in both directions. Roller bearings and nylon bushings were also added to the carriage guide shafts. These additions greatly improved the operating characteristics.

A copy of the plans for the machines may be obtained from either Fire Management or Engineering, Forest Service, USDA, Missoula, Mont.

Fire Prevention Inspection Pays Big Dividends

Franklin O. Carroll

The inspection of internal-combustion engine-driven machinery pays big dividends. How do we know? Listen to this: In 1964, the Southwestern Region of the Forest Service initiated a machinery inspection program. In just 1 year, the number of fires started by equipment dropped from an average of twenty-seven to nine. In the intervening years, that number remained between seven and fourteen, with an average (1965-1974) of twelve. More important was the reduction in acreage losses from an average of 20,000 per year to 2,000 acres annually. This 56 percent reduction in equipment fire numbers and 90 percent reduction in acreage loss represents a tangible and substantial success.

The inspection procedure is simple. All it does is to formalize inspection procedures that have been sporadically performed in the past. The purpose is to insure that the machinery and related equipment, such as spark arresters, meet Forest Service standards.

The present inspection policy requires that all internal-combustion engine-driven machinery be inspected prior to its use on the National Forests, and at least twice during the spring and critical summer fire seasons.

The first inspection is made within 10 days prior to March 1 and the second within 10 days prior to June 1. In any case, an inspection is made prior to use of machinery on the National Forest. The two-inspection

Please turn to page 18

OWNER/OPERATOR CERTIFICATE

I hereby agree to repair, replace or correct all deficiencies indicated on this inspection form before operating this/these machine(s) on National Forest land. I will request a final inspection from the Forest Officer in Charge after making the indicated corrections and before operating this/these machine(s) on National Forest land.

2-20-75 — Date

J. F. Snyder — Signature of Owner or Auth. Repr.

FEDERAL AND STATE LAWS AND REGULATIONS GOVERNING FIRE PREVENTION ON NATIONAL FORESTS AND OTHER LANDS WITHIN THE STATES:

U. S. Secretary of Agriculture Regulation 36 CFR 261.2, (f.) and (j.), Fire Trespass.

Arizona Revised Statutes 13-941 and 13-943.

New Mexico Revised Statute 40A-17-2.

Violations of these laws and regulations are misdemeanors or petty offenses subject to fines, injunctions and/or imprisonment.

INSTRUCTIONS: If equipment is not approved, have equipment owner-operator sign and date copy. Otherwise, no signature is necessary.

DISTRIBUTION: Original to equipment owner.
Copy — retain for administration.
Extra copies — send to adjacent units if this equipment is expected to be moved within the inspection period. Where? Indian Head R.S.

REF: FSM 5113.3

FIRE PREVENTION INSPECTION FOR MACHINERY AND EQUIPMENT

U. S. Department of Agriculture
FOREST SERVICE
Southwestern Region

District: Roaring Fork — Forest: Rock Butte — Page 1 of 1

Name and Address of Owner/Operator: J. F. Snyder, Snyder Logging Co.
Box 317, Ourtown, AZ 85716

Inspection Period: (P/C for next inspection period). March-May ☒ (Green) June-February ☐ (Red)

NOTICE: NO INTERNAL COMBUSTION ENGINE-DRIVEN MACHINERY MAY BE OPERATED ON NATIONAL FOREST LAND UNTIL ALL REQUIREMENTS DESCRIBED IN THE CONTRACT, PERMIT OR AGREEMENT HAVE BEEN COMPLIED WITH, AND UNTIL THE MACHINERY HAS BEEN INSPECTED AND APPROVED BY THE FOREST OFFICER IN CHARGE.

KIND OF MACHINE — Identify each unit by kind and Serial Number or other identification.	*UNIT EQUIPMENT: Shovel	Axe	Spark Arrester	Muffler	Fire Exting.	BP Pump	If approved, insert Sticker Number, Date, and Forest Officer's name. (Otherwise, leave blank).		
Tractor, D-7, 3815CL50	✓	✓	O		✓		3275	2/20/75	FOCarroll
Powersaw, XL-5, XL532974	✓		✓		✓		3276	2/20/75	FOCarroll
Powersaw, PD-3, 57218PZ	✓		O		✓		3277	2/20/75	FOCarroll

*Each unit must be equipped with approved and serviceable items as required. A (✓) indicates approved equipment, a (O) indicates unsatisfactory equipment or lack of required equipment.

R3 5100-4 (7/74)

FIRE MANAGEMENT

Franklin O. Carroll is Assistant Director of Fire and Air Management, Southwestern Region, Forest Service USDA, Albuquerque, N. Mex.

Firefighter's Work Environment And Physical Demands Studied

Richard G. Ramberg and Arthur H. Jukkala

The USDA Forest Service is concerned with man's ability to perform arduous work on fires during hot weather. Very little information has been recorded about working conditions on a fireline or the physical demands placed on firefighters. As a result, in FY 1970 the Division of Fire Management funded a study to gather data on the firefighter, his work environment, and work output. This will assist fire managers in determining worker rest requirements, drinking water intake, and fireline production rates. Such information is also essential for designing tools, clothing, and safety equipment for firefighters.

Dr. Brian Sharkey of the University of Montana Human Performance Laboratory assisted the Missoula Equipment Development Center in designing the study. Data gathering was planned for computer analysis in two major categories: fireline production rates and firefighter physiology and work environment. For four fire seasons, data collectors tested selected fire crews from throughout the West. Measured variables in the study included fireline grade, resistance to control, rate of spread, smoke rating, number in crew, crew fitness level, worker pulse rate, perceived effort, elevation, hours on the job, and percent slope, as well as a wet globe thermometer (WGT) reading — a composite measurement of ambient air temperature, relative humidity, and radiant heat.

Arthur H. Jukkala is a Forester and Richard G. Ramberg is an Equipment Specialist located at the Missoula Equipment Development Center, Forest Service, USDA, Missoula, Mont.

Production Rates

The measured, independent variables were tested against fireline production rates. Of the 12 parameters measured, elevation of the work site, number of workers in the crew, hours on the job, resistance to control, rate of fire spread, and steepness of the slope had the greatest effect on line production. However, measured variables explain only about half the variation in line production, indicating that production is greatly affected by factors we did not measure such as motivation, espirit de corps, crew skills, training, and supervision.

We expected that fireline production would be slower at high elevations. That was not the case—as elevation increased, production increased. Therefore, when considering the elevation parameter in fireline production, fuel conditions appear more influential than human physiological factors relating to oxygen supply. Another interesting finding was that production rates were higher with small crews. Unfortunately the limited data on this facet of our study does not allow us to recommend an optimum crew size.

Substantial fireline data were collected in several fuel types. Measured fireline production rates were compared to available fuel type-guides. In most cases our measured rates were drastically lower than those listed in the guidelines. For example, on four fires in California type 12 fuels, the guides listed a production rate of 0.70 chains per man-hour; fuel Model B listed 0.50 to 0.90 chains per man-hour; and our measured rates on the four fires were 0.32, 0.12, 0.12, and 0.21 chains per man-hour—roughly one-third of the predicted rates. Unfortunately, we did not get enough data in most fuel types to enable us to recommend specific adjustments to existing guides. National or Regional follow-up studies are needed for gathering additional fireline production data to update existing guides. For fire suppression planning, we feel fuel type-ratings are needed that are more specific than existing fuel models.

Firefighter Physiology And Work Environment

The Occupational Safety and Health Act (OSHA) passed in 1970, called for standards for working in hot environments, ". . . to protect workers by minimizing the risk of heat disorders . . . so that workers' health and well-being will not be impaired." The National Institute for Occupational Safety and Health (NIOSH) published preliminary standards, primarily based on industrial needs. These provide an interesting comparison to the en-

vironment on wildland fires. For example, NIOSH initially established a heat stress value of 79° F wet bulb globe temperature (WBGT), which is equivalent to a 72° F wet globe temperature. Most of our WGT readings on actual fires ranged from the 50's to low 70's. Readings in the 80's, 90's, and 100's were occasionally registered, indicating a stressful work environment. Using the proposed criteria, heat stress occurred only during 17 percent of the work shifts we monitored. All heat stress situations encountered by the crews involved in our study were next to a flame front, although heat stress situations can be encountered in high temperatures or high humidity.

NIOSH determined that the deep body temperature cannot exceed 100.4° F without endangering the worker. For example, if a heart rate reaches 180 beats per minute, the deep body temperature will rise to 103.6° F. Heart rate monitoring is a good method for assuring that the deep body temperature does not go above the proposed standard.

From the fire data we found that pulse rates were not much higher on hot days, indicating that crews pace themselves quite well. Firefighters in the first three levels of the Forest Service physical fitness ratings are able to accomplish most tasks without endangering their health. Research has shown that when an individual is exposed to heat, blood is diverted from working muscles to the skin to aid in heat dissipation. Physically fit individuals have a larger heart stroke output (therefore a lower heart rate) and larger blood volumes than unfit workers.

In heat stress conditions, the pro-

Please turn to page 18

Firefighter's Work Environment and Physical Demands Studied

from page 17

posed standard requires that employers furnish 8 quarts of 0.1 percent salted drinking water per man per shift to prevent dehydration. Firefighters we studied are drinking only an average of 2 quarts per shift, or about one-third of thewater they should have.

We recorded the length of rest breaks and counted pulse rates at the end of the breaks. The shortest break we recorded was 5 minutes. Twenty-three percent of the pulse rates recorded were above 100 beats per minute. The proposed standard suggests the worker's pulse rate should drop to 110 beats per minute after the first minute of the rest break and it should continue to drop to 100 beats per minute in the next 3 minutes. If pulse rates are not 100 beats per minute after a 3 minute break, breaks are too short, the work load is extremely heavy, or a heat stress situation exists.

Based on our information, heat stress will be encountered on a relatively small percentage of fires or portions of a fire, and then only for limited periods. Compliance with the proposed standards for hot environments, such as acclimatization, heat monitoring, and medical record keeping, would require wildland fire protection agencies to treat every fire as a heat stress situation. This would be extremely costly and time consuming and for this reason the Forest Service has requested an exemption from the standards. However, it is important that fire managers recognize the purpose of the standards and work toward meeting their intent.

To do this, fire managers must be able to recognize heat stress situations. This can be done by:

- Taking WGT measurements.
- Recognizing that all stress situations we encountered were adjacent to a flame front.
- Measuring pulse rates.

To minimize heat stress problems and prevent heat stress situations, fire managers can:

- Assign only physically fit workers to fireline duty.
- Avoid working crews close to flames or flame fronts. Back off a few feet. If you must work close to a flame front, increase manpower and recognize the need for resting firefighters in a cool spot if possible.
- Schedule work for the coolest parts of the day. Work night shifts when safe to do so and get day shifts on the line early.
- Give firefighters lots of water—2 gallons per shift. Remember, the firefighters we studied drank only about one-third of the water they needed.
- Mechanize the firefighting operation as much as possible to minimize physiological workloads.

A report that discusses our findings in greater detail is available from the Equipment Development Center in Missoula, Mont. Ask for Project Record "Firefighters Physiology Study," June 1974.

Fire Prevention Inspection Pays Big Dividend

from page 15

sequence covers yearlong woods operations, since much of the Region's area is without snow in winter and received little rain otherwise.

A 2-inch, round vinyl sticker, colored green or red, placed on the machine, indicates Forest Service approval for the proper period. A form is used to record the inspection. Extra copies are given to the equipment operator and to adjacent units if the equipment is expected to be moved within the approved inspection period.

Federal and state laws and regulations provide means to require equipment operators to submit to inspection and to repair or maintain their equipment in satisfactory condition. Timber sale and other con-

tracts make the inspections a requirement.

We believe the reasons for the inspection program's relative success is that we have positively identified and effectively treated those elements which are responsible for fires started by equipment. This same analytical procedure applies to any segment of a successful fire prevention program.

A 2-inch, round, vinyl sticker, colored green or red, placed on the machine indicates approval for the current period.

Wilderness Fire Management

from page 11

entire new realm of air operations and firefighting activities, much of which can be applied to wilderness area fires.

Training Important

No great magic is necessary to use these concepts on large wilderness fires. Qualified fire overhead and well-trained suppression crews need only be well briefed by top land managers on exactly how they want the fire job accomplished. New philosophies need to be instilled: Is fire only bad? Is burned acreage alone so almighty important? Qualified fire people can fight fire any way we want them to do it. They need only to know the desired goals. Who knows, once we instill this new philosophy, some, not necessarily all, but some of these new principles might well be applied to fighting fires on National Forest lands outside of wilderness areas as well.

Device May Aid In Fire Control

Forest Service scientists at the Intermountain Forest and Range Experiment Station's Northern Forest Fire Laboratory in Missoula have field-tested a device that measures the amount of moisture in forest fuels.

Mr. Rodney A. Norum, researcher in fire management application studies, says the instrument is effective, accurate, and will prove especially helpful in choosing the best times for prescribed burning. Prescrihed burning is planned and conducted under supervision to improve wildlife habitat, enhance range conditions, remove excessive fuels that can result in large, undesirable wildfires, and, sometimes, to improve forest esthetics.

Dr. Bruce McLeod, Associate Professor of Electrical Engineering at Montana State University, developed the measuring device after consulting with the Forest Service scientists as to need and desired capabilities. He also supervised the testing procedures. Under Dr. McLeod's direction, university students constructed the instrument over a 2-year period. Financing for the project was provided by a grant from the Montana Water Resources Institute.

The battery-powered meter weighs 23 pounds and is portable. When sample duff or other forest fuel is placed in the unit, moisture is measured by the microwave power that is absorhed by the duff. A high amount of power absorbed shows a high moisture content.

The Forest Service has purchased two of the units: one is being tested hy the Intermountain Forest and Range Experiment Station; the other is being evaluated by the Pacific Northwest Forest and Range Experiment Station, Portland.

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Physical Fitness for Firefighters Can You Measure Up?

from page 5

trained interregional crews who have stringent physical fitness requirements have long shown their superiority. Even well-trained and experienced crews who have not been involved in a regular physical fitness program are vastly inferior to the fit crew when compared on a production basis. The longer and harder and usually the more critical the situation, the more noticeable the difference. The time has come to recognize that only people sufficiently fit for the job will be used. Limiting the hard work a person does all year to his or her brief assignment to a wildfire is not acceptable.

In summary, the Forest Service has formally adopted physical fitness standards for firefighters as measured by the step test. The requirement is in terms of aerobic capacity, which is directly related to endurance. The average American can meet the requirements providing he is physically active, not overweight, and in good health. Minimum physical fitness levels are necessary for safe productive work in a wildland logical fire situation.

[1, 2, 3] Sharkey, Brian J., *Physiological Fitness and Weight Control*, Mountain Press Publishing Co., 1973

Explosives Build Fireline In Canada

from page 9

Data should be collected to determine the true limits of the cord according to fuel types.

The methods of initiation of the cord will be examined to ascertain the most suitable and the safest detonating system.

Safety is of prime concern so restraints must be placed on the areas where it can or cannot be used.

Training demonstrations on the advantages and best use of the cord will be held for ranger staff throughout the province.

Firebase Reports Available

FIREBASE is a computer designed program for multinational systematic input, storage, and retrieval of literature, data, and other information pertinent to the management and effects of wildland fire.

Progress Report No. 2 of the fire information portion of the Forestry Technical Information System (FTIS) is now available, according to Dr. Roger R. Bay, Director of Intermountain Forest and Range Experiment Station. Alan R. Taylor, Project Director, and Edward E. Mathews, Forestry Technician, developed the report for the FIREBASE Project headquartered at the Northern Forest Fire Laboratory in Missoula.

The report informs the potential user of the system of progress and changes in system design and direction of growth. The first progress report was sent to about 600 people and some of the changes made in the latest one are direct results of reader response to that report. One example is that abstracts, or digests, have been modified to include a paragraph specifically for the laymen interested in forestry information.

The Forest Service is leading the development of the computerized information retrieval system which will eventually contain several functional information bases and will provide on-line time share and hard copy information services to the public, land managers, and scientists.

Copies of Progress Report may be obtained by writing Taylor at the Northern Forest Fire Laboratory, Drawer G, Missoula, Mont. 59801.

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